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STEM ROT OF GROUNDNUT INCITED BY SCLEROTIUM ROLFSII SACC. AND IT'S MANAGEMENT - A REVIEW

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ABSTRACT

Groundnut (Arachis hypogaea L.) is an important oilseed crop. The low productivity in groundnut is attributed to many production constraints. Among these, biotic factors, particularly diseases play a major role in limiting the yield of groundnut. It is most affected with the pathogen Sclerotium rolfsii sac, which is a soil-borne pathogen and causes disease in different crops including peanut. Biological control is an alternate source by introducing soil borne pathogens, which helps in suppressing the disease. While in combination with biocontrol agents and fungicides for seed treatment, it was effective in suppressing the pathogen, besides reducing the environmental hazards and cost of cultivation. This paper reviews the literature on Sclerotium rolfsii, inducing stem rot disease and its management.

KEYWORDS: Groundnut, Sclerotium Rolfsii, Biological Control & Management

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A Review Article

INTRODUCTION

Groundnut is called as the 'King' of oilseeds. It is one of the most important food and cash crops of our country. While being a valuable source of all the nutrients, it is a low priced commodity. Groundnut is also called as wonder nut and poor men's cashew nut. Groundnut is one of the most important cash crops of our country. It is a low priced commodity, but a valuable source of all the nutrients. Groundnut is grown on 26.4 million ha worldwide with a total production of 37.1 million metric t and an average productivity of 1.4 metric t/ha. India occupies the first place, both in regard to the area and the production in the world. In India groundnut is mostly grown in 5 states viz. Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra, which accounts for 80 percent of the total area and production of groundnut (Reddy, 1992). Groundnut seeds are valued for oil (40-48%) and protein (22-26%) also contain carbohydrate (26%) fat (3%) and high calcium, thiamine and niacin contents, which make a substantial contribution of protein for human and animal nutrition (Maiti *et al.,* 1991). The major production constraints are unreliable and erratic distribution of rainfall and appearance of unpredictable diseases and pests accounting for low productivity. Diseases are one of the major constraints responsible for the low productivity. Several fungal species have been reported to be associated with groundnut seed. Among the different pathogens attacking the crop, *Aspergillus Niger*, *Aspergillus flavus*, *Rhizoctonia bataticola* and *Sclerotium rolfsii* are the most important fungi causing seed and seedling rots and stem rot diseases. Among the soil-borne fungal diseases, stem rot caused by *Sclerotium rolfsii* is a potential threat to successful groundnut cultivation. This disease causes severe damage near maturity and yield losses over 25% have been reported by Maya and Datar (1988). The *Sclerotium rolfsii* has an extensive host range, prolific growth rate and ability to produce large numbers of sclerotia that may persist in soil for several years (Punja, 1985). In India, the disease is more severe in Maharashtra, Gujarat,

Madhya Pradesh, Andhra Pradesh, Orissa and Tamil Nadu (Krishnakanth *et al*., 1999). The stem rot caused by *Sclerotium rolfsii* Sacc. has been a major problem in groundnut growing regions. This paper reviews the literature on *Sclerotium rolfsii* inducing stem rot disease and its management.

STEM ROT PATHOGEN

The pathogen *Sclerotium rolfsii* Sacc., is a soil borne pathogen that commonly occurs in the tropics, sub-tropics and other warm temperate regions of the world, causing root rot, stem rot, wilt and foot rot on more than 500 plant species, including almost all the agricultural and horticultural crops (Domsch *et al.,* 1980; Farr *et al.,* 1989). This was first time reported by Rolfs (1892) as a cause of tomato blight in Florida. Later, Saccardo (1911) named the fungus as *S. rolfsii* sp.

MORPHOLOGY OF THE SCLEROTIUM ROLFSII

Sclerotia initially white in colour, later it becomes light brown to dark brown at maturity and they are sub sphere, the surface finely wrinkled, sometimes flattened (Subramanian, 1964 and Mehan, 1995). This pathogen *Sclerotium rolfsii* forms brown sclerosis, which is very well organized, compact structures, built of three layers, the rind, composed of empty melanised cells; the cortex cells, filled with vesicles and the medulla (Chet, 1975). Sclerotia were superficial on the affected part, spherical or ellipsoidal and measured 0.5 mm to 2.5 mm in diameter. Non germinated sclerotia become soft and broke easily. Maceration of cortical cells was common. A bacterium like organism was consistently associated with the ruptured and macerated slot (Narsimha Rao, 2000).

SYMPTOMATOLOGY

Symptoms are typified by the development of white fungal thread over the affected plant tissue. The disease starts with pre emergence rot of seeds characterized by rotten and softened seeds, which are covered by the white profuse mycelial growth of fungus. The pathogen attacks the germinated seedlings and causes wilt. In young seedling, a sheath of white muslin develops on or near the soil line around the affected area of the stem, which later turned to dark brown and small round bodies about the size of mustard like sclerotia seed are produced on the surface of infected tissue and the adjacent soil. Abundant sclerotia initially white and later turning brown, develop in the infected area. Young plants may be completely girdled and killed, a condition is known as foot rot. The pathogen attacks all the parts of the plant, but stem infection is most common and destructive yellowing and wilting of branches near the base is the first symptom.

Mehrotra and Aneja, (1990) noticed the cortical decay of stem base at ground level and appearance of conspicuous white muslin, which extended into the soil and on organic debris. The mycelial mat may extend several centimeters up to the stem above the soil line. Pods and kernels may be affected, on young pods orange, yellow or light tan lesions develop, which darken to brown or black on older pods. In advanced stages of decay, shriveled and covered with wisps of mycelium. The fungus can also cause blue damage (bluish black discoloration of testa) as a result of oxalic acid production. Whitish growth inside shell covers the surface of kernels (Frealin, 1973).

ISOLATION AND MAINTENANCE OF THE PATHOGEN

Sclerotium rolfsii was isolated from different plants viz., diseased seeds and seedlings (Rama Rao and Usharaja, 1980. Uma Singh and Thapliyal, 1998. Rajeevpant and Mukopadhyay, 2001), stem (Kajal Kumar and Chitreswar Sen, 2000), collar region (Ansari and Agnihotri, 2000., Narasimha Rao *et al*., 2004), root (Srikanta Das and Raj, 1995., Harinath Naidu, 2000 and for *et al*., 2005), tubers, crown, leaves and pods (Gupta and Ashu Sharma, 2004). Potato Dextrose Agar

(PDA) was found to be the best supporting medium for *S. rolfsii* (Harinath Naidu, 2000, Gupta and Ashu Sharma, 2004., Gaur *et al*., 2005 and Raoof *et al.*, 2006). *S. rolfsii* can also be maintained on potato sucrose agar medium (Ramarao and Usharaja, 1980).

MASS MULTIPLICATION OF SCLEROTIUM ROLFSII

The pathogen *Sclerotium rolfsii* was mass multiplied on sterilized sorghum grains presoaked overnight in 2 percent sucrose solution (Upadhyaya and Mukhopadhyay, 1986). Different substrate has been used by different workers for mass multiplication of *S. rolfsii in vitro* such as sterilized sorghum grains (Uma Maheswari *et al.*, 2002; Patibanda *et al.* 2002), wet wheat bran: vermiculate (1:1 w/w) (Prasad *et al.,* 1999) and sand maize meal medium (Rajani *et al.* 2006; Anahosur 2001; Dutt and Das, 2002; Rao *et al*. 2004).

PROOVING PATHOGENECITY

Kajal Kumar and Chitreswar Sen, (2000) isolated *Sclerotium rolfsii* from the roots of the affected plants. Inoculations with this isolate produced hundred per cent infection on Groundnut plants, while the control plants remained healthy. Artificial inoculation of the plants with the pathogen was done by different methods. Soil inoculation by the pathogen was studied by several workers. Vinod Dange (2006),Rajani *et al.* (2006) Seedling root dip inoculum was used to induce sclerotial wilt in bell pepper (Anitha Chowdary, 1997).

IN VITRO EVALUATION OF FUNGICIDES, HERBICIDES, BOTANICALS AND BIO-AGENTS AGAINST S. ROLFSII

Effect of Fungicides against S. Rolfsii under in Vitro Conditions

Sclerotial wilt is a serious menace causing complete death of seedling and mature plant. Numerous chemicals inhibited the sclerotial germination and mycelia growth of *S. rolfsii* and efficiently controlled the disease caused by the pathogen on various crops. carboxin was effective to inhibit *S. rolfsii* (Punja., 1982; Patibanda *et al.*, 2002; Rakholia and Jadeja., 2010). The complete mycelia growth inhibition of *S. rolfsii* was reported with saff,tebuconazole, captan, calixin, ril f004, tilt, idofil M-45, contaf, mancozeb, hinosan, thiram, antracol., benlate and manzate (Bhat and Srivastava, 2003; Rout *et al*., 2006; Gupta and Sharma 2004; Sunkad, 2012: Kapadiya *et al*., 2013). Pranab Dutta and Das (2002) studied *in vitro* efficacy of thiram and mancozeb at 0.1% concentration against tomato isolate of *S. rolfsii* and reported that thiram had inhibited 70.3% of mycelial growth and 96.5% of sclerotial production of *S. rolfsii*. Narayana Bhat and Srivastava (2003) evaluated *in vitro* efficacy of captain, thiophanate-methyl and propiconazole at 250, 500 and 1000 ppm concentrations against *S. rolfsii*. Torray *et al*. (2007) reported that tebuconazole and carboxin gave cent per cent growth inhibition of *S. rolfsii*. Johnson *et al.* (2008) reported the inhibition of *S. rolfsii* pathogen with Hexaconazole and Propiconazole at 0.1% and 0.2%. Radhaiah, (2012) also reported that mancozeb @ 0.2% completely suppressed the pathogen. Madhavi (2011MADHURI) reported the *in vitro* evaluation of nine fungicides by poison food technique showed that tebuconazole and combination of carbendazim+mancozeb were effective in inhibiting the mycelial growth (94.1%) followed by difenconazole (93.3%).

In Vitro Evaluation of Herbicides against Sclerotium Rolfsii

The effect of ten herbicides incorporated into PDA in 50, 100 and 500 µg ml-1 reduced the mycelial growth and sclerotial formation of *S. rolfsii, M. phaseolina and F. oxysporum* under *in vitro* by Vyas *et al.* (1986a). Tripathi *et al.* (1988) reported that herbicides 2, 4-D and fluchloralin drastically inhibited the growth of *S. rolfsii* and *R. bataticola*. The

effects of acetochlor, imazethapyr, metachlor, pendimethalin, trifluralin and mixture acetochlor and imazethapyr on the production and viability of *S. rolfsii* sclerotia were evaluated *in vitro* by Pastor and March (1999). Trifluralin and pendimethalin were the most efficient compounds, because they notably reduced the production of viable sclerotia. Madhuri and Narayan Reddy (2013) evaluated eight herbicides tested for their efficacy on *S. rolfsii* by poisoned food technique and found that oxyflourfen, alachlor, quizalofop-p-ethyl and 2, 4-D sodium salt completely inhibited the growth of *S. rolfsii*. Madhuri and Sagar (2016) quizalofop-p-ethyl showed cent per cent inhibition followed by pendimethalin (92.22%), imazethapyr (68.88 %) and oxyflourfen (51.85 %).

Effect of Botanicals against S. Rolfsii

Dutta and Deb (1986) studied the effect of organic and inorganic amendments on the soil and *Rhizosphere microflora* in relation to the biology and control of *Sclerotium rolfsii*. They reported that, leaf extract of *Eupatorium adenophorum* reduced the pathogen population in the rhizosphere. Singh *et al*. (1989) reported that, out of six plant oils tested against *S. rolfsii*, leaf oil of *Azadirachta indica* was found most effective, followed by that from Eucalyptus globules and *Ocimum canum*. Singh and Dwivedi (1990) reported that, the viability of sclerosis was reduced when treated with neem oil. Seshakiran (2002) reported that, *Eupatorium odoralum* L., *C. occidentalis* and *Azadirachta indica* were highly antifungal to mycelial growth of *S. rolfsii*. However, root extract of *Pathenium hysterophorus* L. Exhibited maximum inhibition of mycelial growth of *S. rolfsii*.

In Vitro Evaluation of Bioagents against S. Rolfsii

Garrett (1956) defined the biological control of plant diseases as "any condition under which, survival and activity of a pathogen are reduced through the agency of any living organisms". McMilan *et al.* (1949) suggested that, reduction in germinability of sclerotia was due to the action of antagonistic organisms. Laha *et al.* (1996) reported that sclerotial viability of *S. rolfsii* causing cotton wilt was reduced when immersed in *P. fluorescens* cell suspension or in a cell free culture filtrate. Narasimha Rao (2000) stated that, biological control is an eco-friendly and effective means of reducing the disease through potential antagonistic micro-organisms. Charitha Devi and Reddy (2003) isolated 5 isolates of *Trichoderma spp* and *Pseudomonas sp*, against *Sclerotium rolfsii* causing root rot of groundnut, and reported that *T. harzianum* showed maximum (66.6%) inhibition of *Sclerotium rolfsii*. Manjula (2004) *reported that T. viride pq 1* produced extracellular chitinase and parasitized the mycelium of *S.rolfsii*. Manyar *et al.*,(2004) studied *Fluorescent Pseudomonas* sp. Having the ability to produce the pyoveridine type of siderophores under low iron stores (up to 10 micro M iron in the succinate medium) and reported that purified siderophores and *Pseudomonas* culture have good antifungal activity against the plant deleterious fungi, *viz, Aspergillus Niger, Aspergillus flavus, Aspergillus oryzae, Fusarium oxysporum, and Sclerotium rolfsii.* The principle mechanisms for control of plant pathogens by *Trichoderma* spp. Include mycoparasitism, antibiosis and competition for resources and space (Wood and Tveit, 1955). Varadharajan Karthikeyana (2007) reported Tv1 of *T. viride* caused 69.40% inhibition of the mycelial growth of the pathogen. Rakh (2011) isolated 11 *Pseudomonas spp*., from rhizospheric soil, were evaluated for their antagonistic activity against *Sclerotium rolfsii*. A soil bacterium identified as, *Pseudomonas cf. monteilii 9*, showed highest antagonistic activity against the pathogen *Sclerotium rolfsii*. He reported, the *Pseudomonas cf. monteilii 9* inhibited the *Sclerotium rolfsii* to up 94 % in terms of dry weight. Chanutsa *et al.* (2014) reported 100per cent inhibition in the growth of *S. rolfsii* with culture filtrate of *P. Florescence*. Deepika *et al.* (2014) reported that the culture filtrate of *Trichoderma harzianum* PBT 23 at 50 per cent was found significantly effective in inhibiting the mycelia growth of *S. sclerotiorum, R. solani, S. rolfsii, F. oxysporium B. ceneria* at

a range of 20.6 - 48.9 per cent.

Endophytic Microorganisms in Biological Control

Endophytic organisms are those that colonize the plant internal tissue showing no external sign of infection or negative effect on their host (Schulz and Boyle, 2006). Endophytic bacteria must also be compatible with host plants and able to colonize the tissues of the host plants without being recognized as pathogens (Rosenbleuth and Martinez-Romero, 2006). Exploitation of endophyte – plant interactions can result in the promotion of plant health, and can play a significant role in low-input sustainable agriculture applications for both food and non-food crops.

Antagonistic Activity of Root Endophytes

Endophytic bacteria must also be compatible with host plants and able to colonize the tissues of the host plants, without being recognized as pathogens (Rosenbleuth and Martinez-Romero, 2006). Basically, being saprophytes and with the additional ability of entering the plant as endophyte, mechanisms of antagonism appeared to remain same with that of rhizosphere antagonistic microflora. Ziedan (2006) isolated root endophytes from peanut healthy roots and found that *Bacillus subtilis* abundantly colonized peanut root than *P. fluorescens,* and reported that effectively controls the root and pod rot diseases. Durga Prasad *et al.* (2008) isolated endophytic *Trichoderma* GSEF3 and root endophytic bacteria GRE 29 which showed higher inhibition per cent on *S. rolfsii* growth *in vitro.* Adhilakshmi *et al.* (2013) reported that five isolates of actinomycetes (CBE, MDU, PDK, ANR and SA) out of 30 were found effective in inhibiting the mycelial growth of *S. rolfsii* the stem rot pathogen of groundnut.

IN VIVO STUDIES

For soil borne plant pathogenic fungi, seed treatment and soil applications have been widely used. A brief review of the work done is presented herewith.

Seed Treatment of Biocontrol Agents

Seed treatment of the biological control agent helps the antagonist to grow along with the root, and occupy the rhizosphere with the advantage of being the primary colonizer. Several reports were published on the use of seed treatment method in biological control. Harman *et al.* (1998) suggested the application of *Trichoderma* or *Gliocladium* to seed as an alternative approach to introducing them into the soil. Podile and Dube (1988) reported that seed coating with *P. fluoroscens* (PN-3) controlled stem rot pathogens of peanut (*S. rolfsii* and *R. solani*) in pot experiments. Muthamilan and Jeyarajan (1992) found that seed pelleting with *Trichoderma harzianum* ($5x\ 10^9$ conidia ml^{-1}) as the best treatment in controlling root rot caused by *S. rolfsii.* Bhatia *et al.* (2005) reported that fluorescent *Pseudomonas* PS-I and PS–II coated seed sown in *S. rolfsii* infected soil significantly increased seed germination by 13.1 and 8.5 per cent respectively as compared to control. Singh *et al.* (2013) selected *Trichoderma* spp. and *Pseudomonas* spp. for seed and seedling treatment in tomato, to assess the synergistic effect of compatible isolates for plant growth promotion and management of *S. rolfsii*. He concluded that the application of a consortium of compatible bioagents enhanced the plant growth and biological control of the pathogen in contrast to treatment with single bioagent. Belkar *et al.* (2013) reported that the seed treatment with *Pseudomonas fluorescens* @ 10g/kg of seed+ *Bradyrhizobium japonicum* @ 20g/kg of seed + *Pseudomonas striata* @ 20g/kg of seed with minimum stem rot incidence, i.e. 8.86%, 13.33%, 20.00% at 20 DAS and 17.73%, 33.33% and 40.00% of flowering, respectively.

Soil Application of Biocontrol Agents

While seed treatment gives the advantage of antagonist being the first colonizer of the rhizosphere, soil application has the advantage of inhibiting the pathogen even away from the rhizosphere. Further, as the quantity of inoculum required for soil application is high, in general, better management is obtained with soil application strategy. Soil application of *P. Fluorescence* was effective in controlling collar rot of groundnut incited by *S. rolfsii* (Patil *et al.*, 1998). Soil application of *T. harzianum* @ 60 g kg^{-1} of natural soil reduced stem rot of groundnut caused by *S. Roofs* up to 83 per cent (Biswas and Sen 2000). Biswas *et al.* (2000) observed that application of *T. harzianum* inoculum to soil and seed dressing at the time of sowing in the pots exhibited percent disease reduction through seed dressing from 33 to 50%, and through direct soil application it was 72 to 83%. Sclerotium wilt of groundnut caused by *S. rolfsii* was effectively reduced to 92.58 per cent, when *T. harzianum* was applied @ 10 g, kg $^{-1}$ soil (Patibanda *et al.*, 2002). Soil application of *T. harzianum (H)* inoculum was superior in reducing the percentage disease incidence and increased shoot length (24 g), root length (17.0), and yield 1509 kg ha-1 against root rot of groundnut caused by *Sclerotium rolfsii*, Saralamma and Vithal Reddy (2003)

INTEGRATED MANAGEMENT OF STEM ROT OF GROUNDNUT CAUSED BY *S. ROLFSII*

Asghari and Mayee (1991), reported that, application of *T. harzianum* inoculum and soil drenching with 0.2 per cent carbendazim reduced the stem rot of groundnut caused by 44-60 percent, and increased the pod yields by 17-47 %. Muthamilan and Jeyarajan (1996) found in their glass house studies that, integration of seed treatment with *T. harzianum*, Rhizobium + *T. harzianum* inoculum added to soil 6 days after sowing plus carbendizam (0.1%) soil drenching on 30 DAS was more effective in reducing root-rot of groundnut caused by *S. rolfsii*. Patibanda *et al.* (2002) observed effective control of sclerotium wilt of groundnut caused by *S. rolfsii*, when seed coating with thiram (0.1%) was integrated with soil applicaton of *T. harzianum* @ 4 g kg $^{-1}$ soil. Vanitha and Suresh (2002) conducted a study to investigate efficacy of biological control agents and organic amendments in controlling collar rot of brinjal caused by *Sclerotium rolfsii*, where *Trichoderma viridae* + FYM + dry adathoda leaf powder were found effective. Ramayallareddy (2002) found that integrated use of *T. viride, P. fluorescens,* neem cake and thiram for seed treatment of groundnut improved seed yield and controlled soil microflora *viz., A. niger, Alternaria spp, Curvularria sp, Fusarium spp, Penicillium sp, R. stolonifer, R. solani, S. rolfsii and Verticillium sp.* Arunasri (2003) reported that seedling root dip in thiram @ 0.1 per cent + seedling root dip in *Trichoderma* suspension (T_1) + seedling root dip in *Pseudomonas* spp. (B_1) reduced the *S. rolfsii* incidence in Crossandra to about 6.66 per cent compared to control (73.66%).

CONCLUSIONS

Stem rot caused my *Sclerotium rolfsii* sacc is one of the most important diseases affecting groundnut crops all over world. Presently, greater emphasis has been replaced with biological control, in order to reduce the environmental hazards, to avoid the development of resistant strains and to reduce the cost of cultivation. Combination with biocontrol agents and fungicides was effective against suppressing the pathogen rather than following only the chemical control.

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